PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Process of Manufacturing Corrosion-resistant Precipitation-hardenable Clad Aluminium Alloys

(A Communication to me from abroad by DÜRENER METALLWERKE AKTIENGESELLSCHAFT, of Düren, Germany, a Corporation organised under the Laws of Germany).

I, WILLIAM HANS ARNOLD THIEMANN, Chartered Patent Agent of the firm Albert L. Mond & Thiemann, of 19, Southampton Buildings, Chancery Lane, London, W.C.2, a British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a process of manufacturing a clad aluminium alloy, which is both precipitation-hardenable and corrosion resistant.

It is known that certain precipitation-hardenable aluminium alloys, containing copper and magnesium, after solution treatment and subsequent quenching, are capable of hardening not only at ordinary temperature (natural ageing) but that certain other effects can be obtained by annealing at lower temperatures, preferably below 200° C. (artificial ageing). In artificial ageing, the temperatures employed are also dependent on the duration of the treatment. According to earlier extensive experiments carried out by the Communicators, the result of such treatment is to raise the yield point considerably, and to lower the ductility and deformability. A further disadvantage of the artificial ageing treatment, especially in the region approaching the maximum values of the yield point has been found by the Communicators to be that the resistance to corrosion is considerably impaired by artificial ageing.

It is already known that precipitation-hardenable copper- and magnesium-containing aluminium alloys which contain silicon in amounts exceeding the limits of natural impurity, are particularly suitable for artificial ageing. However, even in the case of these alloys, the same defect of insufficient resistance to corrosion, after subjecting the material to artificial ageing, has been found to exist.

Aluminium alloys, free from copper, but containing magnesium and silicon (and also manganese and other elements if desired) are also known, which while having medium mechanical properties, are distinguished by very notable resistance to corrosion, even against the action of sea water. Like the cupriferous alloys, these also can be hardened, partly by natural, and partly by artificial ageing, always after solution treatment and quenching. These copper-free alloys do not exhibit the said defect of impaired resistance to corrosion when aged artificially. From this standpoint, therefore, the application of this treatment does not reduce the scope of employment of the copper-free alloys, but such restriction is imposed by their inadequate mechanical properties, which are greatly inferior to those of the aluminium alloys containing both copper and magnesium.

Cupriferous, but magnesium-free, alloys have been proposed as the core alloys for clad alloys. Such alloys, however, are inferior, in respect of mechanical properties, to the alloys according to the invention, particularly as regards yield point and tensile strength, and especially when pure aluminium was employed as the coating metal, as was mostly the case.

It is also known to cover a precipitation-hardenable cupriferous aluminium alloy of low magnesium content, with a copper-free aluminium alloy which is precipitation-hardenable under similar conditions. The union of the two alloys, either as a unilateral facing or preferably on both sides of the core alloy, is effected by known methods, such as welding by hot rolling. This clad alloy is then treated, in the manner usual for such alloys, by heating to solution temperature, quenching and natural ageing, as is described, for example, in specification No. 370,947. It is also stated in this specification that if such clad alloys be artificially aged i.e. at temperatures between 100° and 150° C., which are used for the artificial ageing of copper-free aluminium alloys, they undergo a reduction in the strength of the base or core

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and incidentally a reduction in the yield point.

According to the present invention, there is used a corrosion-resistant precipitation-hardenable clad aluminium alloy, comprising as core metal a precipitation-hardenable aluminium alloy consisting of from 2.0—5.0% copper, 0.3—2.0% magnesium, 0.2—1.5% silicon and 0.2—1.5% manganese, and as covering layer, a precipitation-hardenable aluminium alloy, containing magnesium, silicon and manganese within the same limits but no copper, said clad alloy, after heating to solution-temperature and quenching, being subjected to artificial ageing within a range of temperature from 130° C. up to 230° C. until after an initial softening effect particularly high yield points are attained.

The duration of the artificial ageing depends on the annealing temperature selected and in such a manner that with a low annealing temperature a longer annealing period is required than in the case of a higher temperature. The annealing must be prolonged until after initial softening, the yield point has risen above the original value of the naturally aged alloy.

Proof of this is given for example, by reference to the curves of the accompanying drawing, which were plotted as a result of tests carried out on an alloy containing 4.2% copper, 0.9% magnesium, 0.4% silicon, 0.2% manganese, the remainder being aluminium containing 0.3% iron as impurity.

In these tests, test pieces of sheets of this alloy were heated for about 30 minutes at 500° C. quenched in cold water and stored for about 8 days at room temperature, during which time natural ageing took place in known manner. The individual test pieces were subsequently annealed for either 1, 5 or 25 hours at temperatures between 20 and 270° C., the tensile strength, yield point and elongation (measured for a length $L = 11.3\sqrt{Fo}$ where L is the length and Fo is the cross sectional area of the test bar) being determined after rapid cooling.

With a given annealing period, for example of one hour, the yield point and tensile strength first fall slightly with increasing temperature, as will be seen from the drawing. Then follows the range which is of importance from the point of view of the present invention, since the yield point above all then rises again steeply to a maximum value, which lies considerably higher than the initial value of the yield point of the workpiece hardened at room temperature. At a still higher annealing temperature the material again loses its high quality with respect to the yield point which finally becomes considerably less favourable than in the original condition after natural hardening. The elongation on the other hand, behaves in approximately the reverse manner. It first increases somewhat only to drop considerably within the range in which high yield point values are reached. After reaching its lowest value it gradually rises again with increasing temperature.

The curves have the same characteristic shape for the different annealing periods, the only difference being that the maximum and minimum values respectively are displaced in the direction of lower temperatures as the annealing period increases.

It transpires from these curves that for a given annealing temperature as the annealing period is increased the yield point and mechanical strength sink somewhat, subsequently the yield point rises again to an outstanding degree and leads to the high values which are utilised in accordance with the invention.

In order to attain high yield points with the above mentioned alloy, it is thus necessary to anneal for a period of at least 25 hours at a temperature of 150° C. in accordance with the curves given, whereas if the temperature be raised to 170° C. the time necessary is only at least 5 hours, and at a temperature of 200° C. only at least one hour is necessary. In order to attain the desired high yield points the following annealing periods have been found to be most suitable for the given temperature ranges:

at 150° C. 3 to 10 days
at 170° C. 15 to 50 hours
at 200° C. 2 to 6 hours.

If the alloys have been subjected to cold working prior to annealing, the annealing periods may be reduced and especially when using a low annealing temperature. Moreover, the annealing periods are also influenced by the composition of the alloys, shorter periods being sufficient more particularly when the alloy has a high silicon content.

Particularly favourable results are obtained with the treatment of the present invention, when the core and covering alloys have a silicon content exceeding the amount needed for the formation of the compound Mg_2Si.

By way of example, in carrying out the invention, alloys containing 3 to 5% of copper, 0.5 to 1.0% of magnesium, 0.5 to 1.2% of manganese and 0.8 to

1.5% of silicon are used as core alloy, whilst alloys of similar composition, but free from copper, are used as facing alloy.

Thus, a plate consisting of an aluminium alloy containing 4.5% of copper, 1.0% of manganese, 0.75% of magnesium and 1.0% of silicon was faced on both sides, by hot rolling, with an alloy of similar composition, but not containing copper, being then heated to about 505° C. and quenched. After natural ageing, the clad alloy had a yield point of about 29 kg. per sq. mm. a tensile strength of about 46 kg. per sq. mm. and an elongation of about 20%. By artificial ageing, in accordance with the invention, by annealing at 160° C. for 20 hours, the yield point was increased to about 44 kg. per sq. mm., and the tensile strength to about 50 kg. per sq. mm., the elongation decreasing to about 10%. After exposure to the action of artificial sea water for one year, this artificially aged clad alloy still retained the same mechanical properties unaltered.

The fact that such alloys would retain their capacity for resisting corrosion after artificial ageing, could not be foreseen by those skilled in the art. This behaviour is based in the special character of the precipitation - hardening phenomena which occur in the annealing of such alloys. In respect of mechanical properties, the temperature range round about 180° C. causes an initial softening effect which is succeeded by a renewed hardening, accompanied by a loss of elongation. Little is still known regarding the chemical properties of the material, while in this condition, even in the case of the simple alloys constituting the clad alloy. Still less was known or predictable, therefore, in regard to the manner in which the hardened clad alloy of the present invention, would behave when attacked by corroding agents. Since materials with a particularly high yield point are often required in industry, and, in respect of which a certain loss of elongation can be accepted, but, on no account, a lack of high capacity for resisting corrosion; the sphere of application of precipitation-hardenable aluminium alloys is correspondingly enlarged by the present invention.

Having now particularly described and acertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1). A process of manufacturing a corrosion-resistant precipitation-hardenable clad aluminium alloy comprising a core consisting of a precipitation-hardenable aluminium alloy containing from 2.0 to 5.0% copper, 0.3 to 2.0% magnesium, 0.2 to 1.5% silicon and 0.2 to 1.5% manganese and a facing consisting of a precipitation - hardenable aluminium alloy containing magnesium, silicon and manganese within the same limits but no copper, which process comprises subjecting said clad metal after solution heat treatment and quenching, to artificial ageing within a temperature range from 130° C up to 230° C. until after an initial softening effect particularly high yield points are attained.

2). Process as claimed in claim 1, in which the core and facing consist of aluminium alloys containing silicon in an amount exceeding that required for the formation of the compound Mg_2Si.

3). The process of manufacturing corrosion-resistant precipitation-hardenable clad aluminium alloys, substantially as described.

4). A corrosion - resistant clad aluminium alloy which comprises a core consisting of a precipitation-hardened aluminium alloy containing from 2.0 to 5.0% copper, 0.3 to 2.0% magnesium, 0.2 to 1.5% silicon and 0.2 to 1.5% manganese and a facing consisting of a precipitation-hardened aluminium alloy containing magnesium, silicon and manganese within the same limits but no copper, whenever produced by the processes claimed in any of claims 1 to 3.

Dated this 17th day of November, 1936.

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[This Drawing is a reproduction of the Original on a reduced scale.]